MULTILEVEL COMPUTER MODEL OF WORLD DEVELOPMENT SYSTEM

User Oriented Descriptions

A SERIES: PART IV. ENERGY-EMISSION-REGISTER

Günther Fischer

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ENERGY-EMISSION-REGISTER

ABSTRACT

The Energy-Emission-Register takes as an input the results from the M.P. Energy Supply-Model, i.e. time-series for the annual energy input by energy type and user sector.

Four steps are involved in the computations of the emission model. At first all emissions are computed individually, and then they are added according to different schemes.

A. Emissions by Energy Type: Four different energy types are considered, i.e. solid fuels, liquid fuels, gaseous fuels and nuclear energy.

B. Emissions by Technology: Emissions from five user sectors are considered: electrical power generation, central heat plants, transportation, industry, residential/commercial sector.

C. Total Emissions: CO_2, SO_2, hydrocarbons, nitrogen oxides and aerosols.

D. Accumulated Total Emissions.

For more details see [4].

I. MATHEMATICS OF THE MODEL

A. Notation

In order to simplify the documentation of the mathematics of the Energy-Emission-Register a vector notation is used:

Fossil primary energy sources $\hat{X}$

$$\hat{X} = (S, L, G)$$

where

S = solid fuels

L = liquid fuels

G = gaseous fuels

To denote the i-th element i = 1,2,3 X_i will be used.

User sectors $\hat{Y}$

$$\hat{Y} = (E, H, T, I, R)$$

The components denoting the following:

E = electrical power generation

H = central heat plants

T = transportation

I = industry

R = residential/commercial.

When referring to the j-th element j = 1,...,5 Y_j will be used.

Emissions $\hat{Z}$

$$\hat{Z} = (COM, CO2, SO2, CHX, XNO, AEO)$$

using

COM = carbon monoxide

CO2 = carbon dioxide

SO2 = sulphur dioxide

CHX = hydrocarbons

XNO = nitrogen oxides

AEO = aerosols

When referring to the k-th element k = 1,...,6 Z_k will be used.

Using the above vector abbreviations input energies and emission factors are addressed in the following way:

EX_iFY_j = specific energy source , $i = 1,...,3$; $j = 1,...,5$,

$FZ_kY_jX_i$ = specific emission coefficient , $i = 1,...,3$; $j = 1,...,5$; $k = 1,...,6$.

To give an example:

EX_2FY_3 = ELFT = liquid fuel input going to transportation sector .

Considering nuclear energy the following variables appear:

ENUC = nuclear energy input .

$\hat{FRADW}$ and $\hat{RADW}$ are used for emission factors and actual emissions respectively. The vector $\hat{W}$ is defined as:

$$\hat{W} = (U, P, F)$$

Where its components denote the following:

U = from reactor operation

P = from nuclear fuel production and recycling

F = from shut-down reactors and fuel plants.

B. Model Equations

In the model all emissions are calculated individually from the input data and the emissions are then added according to different schemes. Emissions are:

$$Z_k Y_j X_i = EX_i FY_j \cdot FZ_k Y_j X_i \quad , \qquad \begin{matrix} i = 1,2,3 \\ j = 1,\ldots,5 \\ k = 1,\ldots,6 \end{matrix} .$$

for fossil fuels and

$$RADW_l = ENUC \cdot FRADW_l \quad , \qquad l = 1,2,3 \quad .$$

for nuclear energy

Now four steps are involved in the calculations of the model:

(1) Emissions by Energy Type:

$$Z_k X_i F = \sum_{j=1}^{5} Z_k Y_j X_i \quad , \qquad \begin{matrix} k = 1,\ldots,6 \\ i = 1,2,3 \end{matrix} .$$

(2) Emissions by Technology:

$$Z_k Y_j = \sum_{i=1}^{3} Z_k Y_j X_i \quad , \qquad \begin{matrix} j = 1,\ldots,5 \\ k = 1,\ldots,6 \end{matrix} .$$

(3) Total Emissions:

$$Z_k TOT = \sum_{j=1}^{5} Z_k Y_j = \sum_{j=1}^{5} \sum_{i=1}^{3} Z_k Y_j X_i \quad , \qquad k = 1,\ldots,6 \quad .$$

(4) Accumulated Total Emissions

Accumulation of emissions over time t is done separately for the different energy types, technologies and total emissions. The respective equations are:

$$SZ_k Y_j = \sum_t Z_k Y_j \quad , \qquad \begin{matrix} k = 1,\ldots,6 \\ j = 1,\ldots,5 \end{matrix} \quad .$$

to accumulate for energy sectors

$$SZ_k X_i = \sum_t Z_k X_i \quad , \qquad \begin{matrix} i = 1,2,3 \\ k = 1,\ldots,6 \end{matrix} \quad .$$

to accumulate for fuel kinds, and

$$SZ_k = \sum_t Z_k TOT \quad , \qquad k = 1,\ldots,6 \quad .$$

to accumulate total emissions.

Radioactive emissions and wastes are similarly treated:

$$SRAW_l = \sum_t RADW_l \quad , \qquad l = 1,2,3 \quad .$$

An additional feature of the model is to calculate reduced emissions and reduction costs as well as an aggregation of these variables over time.

Reduced emission is computed according to

$$TRZ_k = \sum_{j=1}^{5} (1 - RZ_kY_j) \cdot Z_kY_j \quad , \qquad k = 1,\ldots,6 \quad .$$

Where RZ_kY_j is the reduction factor for diminishing emission Z_k produced by technology Y_j

Reduction costs in turn are:

$$TGZ_k = \sum_{j=1}^{5} FGZ_kY_j \cdot Z_kY_j \quad , \qquad k = 1,\ldots,6 \quad .$$

FGZ_kY_j denoting the respective reduction cost factor.
Aggregation over time t is then:

$$SRZ_k = \sum_t TRZ_k \quad , \qquad k = 1,\ldots,6$$

$$SGZ_k = \sum_t TGZ_k \quad .$$

II. TERMINAL INPUT AND DATA BASE

A. Requests from the Model

Playing with the model requires the input of some specific parameters from the keyboard. For this purpose the model issues some appropriate statements on the keyboard. The following requests may occur:

"READ WATT/M^2"

When starting the model this will be the first request to be issued. You have to enter the average intensity of solar irradiation for the region under consideration (format (F10.1)).

"READ MIO KM^2"

At this request the area of the region has to be entered. Finally the model will ask for

"NDRU (20) INPUT"

The model immediately repeats your input. The values NDRU(I), I = 1,17 are used to control the output of the model, which consists of a table with the used reduction cost and emission factors and up to 17 plots.

The terms in the above requests denote the following:

WATT : Intensity of solar irradiation (in watt/m^2)

AREA : Area to accept the above solar irradiation (in 10^6 KM^2)

NDRU(I), I = 1,..,20: In order to get only a selection of the 17 available plots you may specify NDRU(I) = 1 to get the I-th plot or NDRU(I) $\neq$ 1 to suppress it.

When running the batch version of the model these figures are read from TAPE 3 from the input data deck.

B. Data Base

As mentioned earlier the model takes as an input the output from the Energy Supply Model, i.e. time-series for the annual energy input by energy type and user sector. In addition the model needs a file containing the emission and reduction factors (read from unit number 4). From input device 3 the following data will be read:

REG(I), I = 1,18 : Region label with up to 72 characters
SCE(I), I = 1,18 : Scenario label with up to 72 characters

Both are read with format (20 A4)

JAHR : Year of observation

NR : May be used to put the data cards into order

ESFE : Solid fuel input for electrical power generation

ESFH : Solid fuel input going to central heat plants

ESFT : Solid fuel input going to transportation sector

ESFI : Solid fuel input going to industry

ESFR : Solid fuel input going to residential/commercial sector

ELFE : Liquid fuel input going to electrical power generation

ELFH : Liquid fuel input going to central heat plants

ELFT : Liquid fuel input going to transportation sector

ELFI : Liquid fuel input going to industry

ELFR : Liquid fuel input going to residential/commercial sector

EGFE : Gaseous fuel input going to electrical power generation

EGFH : Gaseous fuel input going to central heat plants

EGFT : Gaseous fuel input going to transportation sector

EGFI : Gaseous fuel input going to industry

EGFR : Gaseous fuel input going to residential/commercial sector

ENUC : Nuclear energy input

EUSE : Total useful energy

EWAST : Waste heat

ETOT : Total energy input

Energy units are 10^9 metric tons of coal equivalent. The data are read with format (I5, 1X, I1, 2X, 7E10.3, 3,2 (1,9X, 7E10.3)). The file name associated with TAPE 3 for the CYBER 74 at the TH-Vienna is EMDAT (see Table 2). From input device 4 the following data will be read (see Table 1).

Reduction Factors: Are used in the model to calculate reduced emissions = (1 - factor) · emissions. There are 30 reduction factors for 6 kinds of emission and 5 user sectors. The factors can easily be recognized from the listing of the computer program, e.g. the factor for the reduction of SO2 in electrical power generation is RSO2E.

Reduction Costs: In order to calculate the costs of reduced emissions, reduction cost factors for SO2 and aerosols for each of the user sectors are used, e.g. FGSO2H is the cost factor for reduction of SO2 emissions in central heat plants.

Emission Factors: There are 93 emission factors regarding 3 kinds of fuel (solid, liquid, gaseous), 6 kinds of emission (CO, CO2, SO2, hydrocarbons, nitrogen oxides, and aerosols), and 5 user sectors, e.g. FCHXGI is the emission factor for emissions of hydrocarbons due to use of gaseous fuels in industry. (G = gaseous fuel, I = industrial sector, CHX = hydrocarbons.) The last 3 factors concern nuclear emissions:

FRADU : Radioactive emission during reactor operation

FRADP : Radioactive emission and waste from fuel production and recycling

FRADF : Radioactive emission from shut-down reactors and fuel plants.

All factors are read with format (6F7.3).

There are two additional data records necessary for the batch version of the model that may be run at the TH-Vienna.

Subsequent to the above emission factors intensity of solar irradiation (in watt/M^2) and the area to accept this irradiation (in 10^6 KM^2) is read with format (2F10.2). The final data card is then used to assign values to the array NDRU for output control. It is read with format (20I1).

Table 1.

```
**************************
ENERGY EMISSION REGISTER.
**************************
      0       0     900       0       0       0       0
      0       0     900       0       0       0       0
      0       0       0       0       0       0       0
      0
      0       0       0       0       0       0       0       0
    740     740       0       0       0
    179     179       0       0       0
    200    3000   20000     100    8500    4500
    200    3000   20000     100    8500    4500
  20000    3000    1100    6000   12000    5000
   1400    3000   25000     400    7000   10000
   5000    3000   20000    5000    3500   20000
    100    3200   23000     200    7000    2000
    100    3200   23000     200    7500    2000
 150000    3200    3500   15000   20000    4000
    200    3200   16000     300    7000    2000
    300    3200     600    2000     200    2000
    100    2700     100     000    5000     100
    100    2700     100     000    5000     100
   5000    2700     100     000    5000     100
    000    2700     100     000    5000     200
    000    2700     100    2000    1500     200
  14700  144000     000
4.5        210.0                                  WATT/AREA
1111111111111111                                  NDRU
```

Table 2.

WESTERN EUROPE
CONSUMPTION CORR.TO 5 KW/CAP OR 10 KW/CAP AT 40 % SAVINGS IN USE (WEU5)

1970	1	0.171E 00	0.900E-02	0.540E-02	0.159E 00	0.105E 00	0.803E-01	0.0
1970	2	0.146E 00	0.203E 00	0.172E 00	0.300E-01	0.0	0.839E-08	0.915E-01
1970	3	0.492E-01	0.100E-01	0.714E 00	0.643E 00	0.144E 01		
1971	1	0.180E 00	0.945E-02	0.522E-02	0.155E 00	0.101E 00	0.807E-01	0.0
1971	2	0.147E 00	0.205E 00	0.173E 00	0.361E-01	0.0	0.677E-03	0.109E 00
1971	3	0.599E-01	0.100E-01	0.735E 00	0.662E 00	0.148E 01		
1972	1	0.188E 00	0.990E-02	0.504E-02	0.150E 00	0.973E-01	0.811E-01	0.0
1972	2	0.148E 00	0.206E 00	0.174E 00	0.422E-01	0.0	0.158E-02	0.125E 00
1972	3	0.708E-01	0.100E-01	0.756E 00	0.681E 00	0.153E 01		
1973	1	0.197E 00	0.104E-01	0.486E-02	0.145E 00	0.933E-01	0.815E-01	0.0
1973	2	0.148E 00	0.207E 00	0.175E 00	0.483E-01	0.0	0.272E-02	0.142E 00
1973	3	0.819E-01	0.100E-01	0.776E 00	0.700E 00	0.157E 01		
1974	1	0.205E 00	0.108E-01	0.468E-02	0.140E 00	0.894E-01	0.819E-01	0.0
1974	2	0.149E 00	0.208E 00	0.176E 00	0.544E-01	0.0	0.408E-02	0.157E 00
1974	3	0.933E-01	0.100E-01	0.797E 00	0.720E 00	0.162E 01		
1975	1	0.214E 00	0.113E-01	0.450E-02	0.135E 00	0.855E-01	0.824E-01	0.0
1975	2	0.150E 00	0.209E 00	0.177E 00	0.604E-01	0.0	0.567E-02	0.173E 00
1975	3	0.105E 00	0.100E-01	0.818E 00	0.740E 00	0.166E 01		
1976	1	0.235E 00	0.124E-01	0.465E-02	0.140E 00	0.874E-01	0.828E-01	0.0
1976	2	0.158E 00	0.206E 00	0.174E 00	0.605E-01	0.0	0.623E-02	0.171E 00
1976	3	0.106E 00	0.100E-01	0.826E 00	0.765E 00	0.169E 01		
1977	1	0.258E 00	0.136E-01	0.477E-02	0.145E 00	0.888E-01	0.832E-01	0.0
1977	2	0.167E 00	0.202E 00	0.172E 00	0.605E-01	0.0	0.680E-02	0.169E 00
1977	3	0.107E 00	0.100E-01	0.834E 00	0.791E 00	0.173E 01		
1978	1	0.281E 00	0.148E-01	0.488E-02	0.149E 00	0.898E-01	0.836E-01	0.0
1978	2	0.175E 00	0.199E 00	0.170E 00	0.605E-01	0.0	0.737E-02	0.168E 00
1978	3	0.108E 00	0.100E-01	0.842E 00	0.817E 00	0.176E 01		
1979	1	0.305E 00	0.161E-01	0.497E-02	0.153E 00	0.905E-01	0.841E-01	0.0
1979	2	0.184E 00	0.196E 00	0.167E 00	0.605E-01	0.0	0.794E-02	0.166E 00
1979	3	0.109E 00	0.100E-01	0.848E 00	0.844E 00	0.180E 01		
1980	1	0.331E 00	0.174E-01	0.504E-02	0.156E 00	0.907E-01	0.845E-01	0.0
1980	2	0.192E 00	0.192E 00	0.165E 00	0.605E-01	0.0	0.851E-02	0.164E 00
1980	3	0.111E 00	0.100E-01	0.855E 00	0.871E 00	0.183E 01		
1981	1	0.360E 00	0.190E-01	0.509E-02	0.160E 00	0.896E-01	0.832E-01	0.0
1981	2	0.198E 00	0.184E 00	0.159E 00	0.640E-01	0.0	0.960E-02	0.172E 00
1981	3	0.118E 00	0.100E-01	0.881E 00	0.897E 00	0.188E 01		
1982	1	0.388E 00	0.204E-01	0.503E-02	0.160E 00	0.866E-01	0.819E-01	0.0

1982	2	0.203E 00	0.176E 00	0.153E 00	0.686E-01	0.0	0.109E-01	0.183E 00
1982	3	0.128E 00	0.100E-01	0.908E 00	0.923E 00	0.194E 01		
1983	1	0.414E 00	0.218E-01	0.486E-02	0.156E 00	0.816E-01	0.807E-01	0.0
1983	2	0.209E 00	0.168E 00	0.148E 00	0.745E-01	0.0	0.126E-01	0.196E 00
1983	3	0.140E 00	0.100E-01	0.935E 00	0.948E 00	0.199E 01		
1984	1	0.438E 00	0.231E-01	0.458E-02	0.149E 00	0.750E-01	0.794E-01	0.0
1984	2	0.214E 00	0.160E 00	0.142E 00	0.816E-01	0.0	0.145E-01	0.213E 00
1984	3	0.155E 00	0.100E-01	0.963E 00	0.971E 00	0.205E 01		
1985	1	0.460E 00	0.242E-01	0.418E-02	0.138E 00	0.669E-01	0.781E-01	0.0
1985	2	0.218E 00	0.152E 00	0.137E 00	0.900E-01	0.0	0.169E-01	0.232E 00
1985	3	0.173E 00	0.100E-01	0.991E 00	0.993E 00	0.210E 01		
1986	1	0.503E 00	0.265E-01	0.356E-02	0.150E 00	0.695E-01	0.761E-01	0.0
1986	2	0.223E 00	0.142E 00	0.129E 00	0.937E-01	0.0	0.184E-01	0.239E 00
1986	3	0.182E 00	0.800E-02	0.102E 01	0.103E 01	0.217E 01		
1987	1	0.545E 00	0.287E-01	0.281E-02	0.160E 00	0.711E-01	0.742E-01	0.0
1987	2	0.229E 00	0.133E 00	0.121E 00	0.980E-01	0.0	0.202E-01	0.247E 00
1987	3	0.192E 00	0.600E-02	0.105E 01	0.107E 01	0.223E 01		
1988	1	0.584E 00	0.307E-01	0.195E-02	0.169E 00	0.720E-01	0.726E-01	0.0
1988	2	0.234E 00	0.125E 00	0.113E 00	0.103E 00	0.0	0.222E-01	0.25?E 00
1988	3	0.204E 00	0.400E-02	0.108E 01	0.110E 01	0.230E 01		
1989	1	0.621E 00	0.327E-01	0.100E-02	0.177E 00	0.721E-01	0.714E-01	0.0
1989	2	0.240E 00	0.117E 00	0.107E 00	0.108E 00	0.0	0.244E-01	0.267E 00
1989	3	0.216E 00	0.200E-02	0.111E 01	0.113E 01	0.236E 01		
1990	1	0.656E 00	0.345E-01	0.152E-07	0.184E 00	0.714E-01	0.704E-01	0.0
1990	2	0.247E 00	0.110E 00	0.101E 00	0.115E 00	0.0	0.268E-01	0.279E 00
1990	3	0.231E 00	0.0	0.115E 01	0.116E 01	0.243E 01		
1991	1	0.711E 00	0.374E-01	0.323E-07	0.197E 00	0.736E-01	0.661E-01	0.0
1991	2	0.237E 00	0.101E 00	0.919E-01	0.120E 00	0.0	0.294E-01	0.290E 00
1991	3	0.245E 00	0.0	0.118E 01	0.120E 01	0.251E 01		
1992	1	0.762E 00	0.401E-01	0.338E-07	0.209E 00	0.748E-01	0.623E-01	0.0
1992	2	0.228E 00	0.923E-01	0.842E-01	0.127E 00	0.0	0.321E-01	0.302E 00
1992	3	0.260E 00	0.0	0.122E 01	0.124E 01	0.258E 01		
1993	1	0.810E 00	0.426E-01	0.350E-07	0.218E 00	0.751E-01	0.591E-01	0.0
1993	2	0.221E 00	0.852E-01	0.776E-01	0.133E 00	0.0	0.350E-01	0.314E 00
1993	3	0.276E 00	0.0	0.126E 01	0.127E 01	0.266E 01		
1994	1	0.853E 00	0.449E-01	0.359E-07	0.226E 00	0.746E-01	0.565E-01	0.0
1994	2	0.216E 00	0.793E-01	0.719E-01	0.140E 00	0.0	0.381E-01	0.326E 00
1994	3	0.293E 00	0.0	0.130E 01	0.131E 01	0.273E 01		
1995	1	0.893E 00	0.470E-01	0.182E-07	0.232E 00	0.733E-01	0.545E-01	0.0

1995	2	0.212E 00	0.744E-01	0.673E-01	0.147E 00	0.0	0.414E-01	0.338E 00
1995	3	0.310E 00	0.0	0.134E 01	0.134E 01	0.281E 01		
1996	1	0.911E 00	0.480E-01	0.352E-07	0.227E 00	0.685E-01	0.531E-01	0.0
1996	2	0.211E 00	0.698E-01	0.642E-01	0.152E 00	0.0	0.441E-01	0.344E 00
1996	3	0.323E 00	0.0	0.137E 01	0.134E 01	0.284E 01		
1997	1	0.928E 00	0.488E-01	0.337E-07	0.219E 00	0.633E-01	0.523E-01	0.0
1997	2	0.212E 00	0.660E-01	0.619E-01	0.156E 00	0.0	0.469E-01	0.350E 00
1997	3	0.336E 00	0.0	0.141E 01	0.133E 01	0.287E 01		
1998	1	0.942E 00	0.496E-01	0.319E-07	0.210E 00	0.579E-01	0.521E-01	0.0
1998	2	0.216E 00	0.630E-01	0.603E-01	0.161E 00	0.0	0.498E-01	0.356E 00
1998	3	0.348E 00	0.0	0.144E 01	0.133E 01	0.290E 01		
1999	1	0.954E 00	0.502E-01	0.299E-07	0.199E 00	0.522E-01	0.525E-01	0.0
1999	2	0.221E 00	0.608E-01	0.594E-01	0.165E 00	0.0	0.526E-01	0.361E 00
1999	3	0.361E 00	0.0	0.147E 01	0.132E 01	0.293E 01		
2000	1	0.964E 00	0.507E-01	0.138E-07	0.186E 00	0.464E-01	0.536E-01	0.0
2000	2	0.230E 00	0.592E-01	0.592E-01	0.169E 00	0.0	0.555E-01	0.365E 00
2000	3	0.373E 00	0.0	0.150E 01	0.132E 01	0.296E 01		
2001	1	0.974E 00	0.513E-01	0.279E-07	0.188E 00	0.459E-01	0.541E-01	0.0
2001	2	0.232E 00	0.598E-01	0.598E-01	0.171E 00	0.0	0.577E-01	0.364E 00
2001	3	0.380E 00	0.0	0.152E 01	0.133E 01	0.299E 01		
2002	1	0.984E 00	0.518E-01	0.282E-07	0.191E 00	0.455E-01	0.547E-01	0.0
2002	2	0.235E 00	0.604E-01	0.604E-01	0.173E 00	0.0	0.599E-01	0.363E 00
2002	3	0.387E 00	0.0	0.154E 01	0.134E 01	0.302E 01		
2003	1	0.994E 00	0.523E-01	0.285E-07	0.194E 00	0.450E-01	0.552E-01	0.0
2003	2	0.237E 00	0.610E-01	0.610E-01	0.175E 00	0.0	0.622E-01	0.362E 00
2003	3	0.394E 00	0.0	0.156E 01	0.135E 01	0.305E 01		
2004	1	0.100E 01	0.528E-01	0.288E-07	0.197E 00	0.445E-01	0.558E-01	0.0
2004	2	0.239E 00	0.616E-01	0.616E-01	0.176E 00	0.0	0.644E-01	0.360E 00
2004	3	0.402E 00	0.0	0.158E 01	0.136E 01	0.308E 01		
2005	1	0.101E 01	0.534E-01	0.145E-07	0.200E 00	0.439E-01	0.563E-01	0.0
2005	2	0.242E 00	0.622E-01	0.622E-01	0.178E 00	0.0	0.668E-01	0.359E 00
2005	3	0.409E 00	0.0	0.160E 01	0.137E 01	0.311E 01		
2006	1	0.102E 01	0.537E-01	0.293E-07	0.202E 00	0.432E-01	0.567E-01	0.0
2006	2	0.243E 00	0.626E-01	0.626E-01	0.179E 00	0.0	0.689E-01	0.356E 00
2006	3	0.415E 00	0.0	0.161E 01	0.137E 01	0.313E 01		
2007	1	0.103E 01	0.541E-01	0.295E-07	0.205E 00	0.425E-01	0.571E-01	0.0
2007	2	0.245E 00	0.631E-01	0.631E-01	0.180E 00	0.0	0.710E-01	0.353E 00
2007	3	0.421E 00	0.0	0.162E 01	0.138E 01	0.315E 01		
2008	1	0.103E 01	0.544E-01	0.297E-07	0.207E 00	0.418E-01	0.574E-01	0.0

2008	2	0.246E 00	0.635E-01	0.635E-01	0.182E 00	0.0	0.732E-01	0.351E 00	
2008	3	0.427E 00	0.0	0.163E 01	0.139E 01	0.317E 01			
2009	1	0.104E 01	0.548E-01	0.298E-07	0.209E 00	0.411E-01	0.578E-01	0.0	
2009	2	0.248E 00	0.639E-01	0.639E-01	0.183E 00	0.0	0.754E-01	0.348E 00	
2009	3	0.433E 00	0.0	0.164E 01	0.140E 01	0.319E 01			
2010	1	0.105E 01	0.551E-01	0.150E-07	0.212E 00	0.403E-01	0.582E-01	0.0	
2010	2	0.250E 00	0.643E-01	0.643E-01	0.184E 00	0.0	0.776E-01	0.345E 00	
2010	3	0.440E 00	0.0	0.165E 01	0.141E 01	0.321E 01			
2011	1	0.105E 01	0.555E-01	0.302E-07	0.214E 00	0.396E-01	0.585E-01	0.0	
2011	2	0.251E 00	0.647E-01	0.647E-01	0.185E 00	0.0	0.798E-01	0.342E 00	
2011	3	0.446E 00	0.0	0.166E 01	0.141E 01	0.323E 01			
2012	1	0.106E 01	0.558E-01	0.304E-07	0.216E 00	0.388E-01	0.589E-01	0.0	
2012	2	0.253E 00	0.651E-01	0.651E-01	0.186E 00	0.0	0.820E-01	0.339E 00	
2012	3	0.452E 00	0.0	0.168E 01	0.142E 01	0.325E 01			
2013	1	0.107E 01	0.562E-01	0.306E-07	0.219E 00	0.380E-01	0.593E-01	0.0	
2013	2	0.254E 00	0.655E-01	0.655E-01	0.187E 00	0.0	0.843E-01	0.335E 00	
2013	3	0.458E 00	0.0	0.169E 01	0.142E 01	0.327E 01			
2014	1	0.107E 01	0.565E-01	0.308E-07	0.221E 00	0.372E-01	0.597E-01	0.0	
2014	2	0.256E 00	0.659E-01	0.659E-01	0.189E 00	0.0	0.866E-01	0.332E 00	
2014	3	0.465E 00	0.0	0.171E 01	0.143E 01	0.329E 01			
2015	1	0.108E 01	0.569E-01	0.155E-07	0.224E 00	0.364E-01	0.600E-01	0.0	
2015	2	0.257E 00	0.663E-01	0.663E-01	0.190E 00	0.0	0.889E-01	0.329E 00	
2015	3	0.471E 00	0.0	0.172E 01	0.143E 01	0.331E 01			
2016	1	0.109E 01	0.576E-01	0.314E-07	0.227E 00	0.358E-01	0.608E-01	0.0	
2016	2	0.261E 00	0.671E-01	0.671E-01	0.192E 00	0.0	0.900E-01	0.331E 00	
2016	3	0.479E 00	0.0	0.174E 01	0.145E 01	0.335E 01			
2017	1	0.111E 01	0.583E-01	0.318E-07	0.231E 00	0.352E-01	0.615E-01	0.0	
2017	2	0.264E 00	0.680E-01	0.680E-01	0.194E 00	0.0	0.911E-01	0.333E 00	
2017	3	0.487E 00	0.0	0.177E 01	0.146E 01	0.339E 01			
2018	1	0.112E 01	0.590E-01	0.321E-07	0.235E 00	0.345E-01	0.622E-01	0.0	
2018	2	0.267E 00	0.688E-01	0.688E-01	0.197E 00	0.0	0.922E-01	0.336E 00	
2018	3	0.494E 00	0.0	0.179E 01	0.148E 01	0.343E 01			
2019	1	0.113E 01	0.597E-01	0.325E-07	0.239E 00	0.338E-01	0.630E-01	0.0	
2019	2	0.270E 00	0.696E-01	0.696E-01	0.199E 00	0.0	0.933E-01	0.338E 00	
2019	3	0.502E 00	0.0	0.181E 01	0.150E 01	0.347E 01			
2020	1	0.115E 01	0.604E-01	0.165E-07	0.243E 00	0.331E-01	0.637E-01	0.0	
2020	2	0.273E 00	0.704E-01	0.704E-01	0.201E 00	0.0	0.944E-01	0.340E 00	
2020	3	0.510E 00	0.0	0.183E 01	0.151E 01	0.351E 01			
2021	1	0.116E 01	0.611E-01	0.333E-07	0.247E 00	0.324E-01	0.645E-01	0.0	

2021	2	0.277E 00	0.712E-01	0.712E-01	0.204E 00	0.0	0.955E-01	0.342E 00
2021	3	0.518E 00	0.0	0.185E 01	0.153E 01	0.355E 01		
2022	1	0.117E 01	0.618E-01	0.337E-07	0.251E 00	0.316E-01	0.652E-01	0.0
2022	2	0.280E 00	0.720E-01	0.720E-01	0.206E 00	0.0	0.966E-01	0.344E 00
2022	3	0.525E 00	0.0	0.188E 01	0.154E 01	0.359E 01		
2023	1	0.119E 01	0.625E-01	0.340E-07	0.255E 00	0.308E-01	0.659E-01	0.0
2023	2	0.283E 00	0.729E-01	0.729E-01	0.208E 00	0.0	0.977E-01	0.346E 00
2023	3	0.533E 00	0.0	0.190E 01	0.156E 01	0.363E 01		
2024	1	0.120E 01	0.632E-01	0.344E-07	0.259E 00	0.300E-01	0.667E-01	0.0
2024	2	0.286E 00	0.737E-01	0.737E-01	0.211E 00	0.0	0.988E-01	0.348E 00
2024	3	0.541E 00	0.0	0.192E 01	0.158E 01	0.367E 01		
2025	1	0.121E 01	0.639E-01	0.174E-07	0.263E 00	0.292E-01	0.674E-01	0.0
2025	2	0.289E 00	0.745E-01	0.745E-01	0.213E 00	0.0	0.999E-01	0.350E 00
2025	3	0.549E 00	0.0	0.194E 01	0.159E 01	0.371E 01		

III. OUTPUT

As described before the actual output is controlled by the array NDRU(I), I = 1,...,20.

Reduction Factors: In order to consider the abatement of emissions, reduction factors $0 \leq$ red. fact. ≤ 1 are used. Reduced emissions are computed using the relationship:

Reduced emission = (1 - red. fact) · emission .

In our present data base reduction factors $\neq 0$ are used only for SO2.

Reduction Costs: Reduction cost factors (units are 10^9 US dollars/10^6 tons of emission) are used to compute reduction costs

Reduction cost = red. cost fact. · emission .

Because abatement technology is very variable, and at present under rapid development, the average cost effectiveness of such technologies cannot be determined very precisely. Therefore , the present data base ought to be used for sensitivity analysis only.

Emission Factors: For each of the five user sectors (i.e. electric power generation, heat plants, transportation, industry and residential/commercial) emission factors for each primary energy source (i.e. solid, liquid and gaseous fuel) are used for CO, CO2, SO2, hydrocarbons, nitrogen oxides and aerosol emissions.

Units are:

10^6 tons of emission/10^9 metric tons of coal equivalent.

Only for CO2:

10^9 tons of emission/10^9 metric tons of coal equivalent.

Nuclear Emissions: In order to compute radioactive emissions due to nuclear energy input, again emission factors are used:

FRADU : Relative radioactive emissions during reactor operation

FRADP : Relative radioactive emissions from fuel production

FRADF : Relative radioactive emissions and waste from shut-down reactors and fuel plants.

The Emission-Model also provides 17 pages of output in the form of plots. The following plots are available:

PLOT 1. Solid Fuel Input

Reproduction of the input scenario of the Emission Model concerning solid fuel input (in 10^9 metric tons of coal equivalent).

ESFE : Solid fuel input for electric power generation

ESFH : Solid fuel input for heat plants

ESFT : Solid fuel input used for transportation

ESFI : Solid fuel input used in industry

ESFR : Solid fuel input for residential/commercial

PLOT 2. Liquid Fuel Input

Reproduction of the input scenario of the Emission Model concerning liquid fuel input (in 10^9 metric tons of coal equivalent).

ELFE : Liquid fuel input for electric power generation

ELFH : Liquid fuel input for heat plants

ELFT : Liquid fuel input used for transportation

ELFI : Liquid fuel input used in industry

ELFR : Liquid fuel input for residential/commercial.

PLOT 3. Gaseous Fuel Input

Reproduction of the input scenario of the Emission Model concerning gaseous fuel input (in 10^9 metric tons of coal equivalent).

EGFE : Gaseous fuel input for electric power generation

EGFH : Gaseous fuel input for heat plants

EGFT : Gaseous fuel input used in industry

EGFR : Gaseous fuel input used for residential/commercial.

PLOT 4. Nuclear and Total Energy Input

Reproduction of the input scenario concerning nuclear and total energy input (in 10^9 metric tons of coal equivalent).

ENUC : Nuclear energy input

EUSE : Total useful energy

EWAST : Waste heat

ETOT : Total primary energy input.

(SOLAR IRRADIATION/ETOT · 100)$^{-1}$: Total energy input created by man compared to solar irradiation of the respective region.

PLOT 5. Total Emission/Year

Total emissions produced by the five user groups.

CO_2 : Carbon dioxide

SO_2 : Sulphur dioxide

CHX : Hydrocarbons

XNO : Nitrogen oxides

AEO : Aerosols.

PLOT 6. Accumulated Emissions

Accumulation of the various emissions (see PLOT 5) from 1970 on.

PLOT 7. Reduced Emissions

Reduced emission of SO_2 and aerosols (both in 10^6 tons) and reduction cost (in 10^9 US dollars) are plotted.

TRSO2 : Reduced emissions of SO2

TRAEO : Reduced emissions of AEO

GSO2 : Reduction costs for SO2-emission reduction

GAEÒ : Reduction costs for AEO-emission reduction.

PLOTS 8-10. Emissions of CO2, SO2, hydrocarbons, nitrogen oxides and aerosols according to the kind of primary energy used, i.e.

Plot 8 : Emissions of solid fuel

Plot 9 : Emissions of liquid fuel

Plot 10 : Emissions of gaseous fuel.

PLOTS 11-15. Emissions of CO2, SO2, hydrocarbons, nitrogen oxides and aerosols according to the user sector, i.e.

Plot 11 : Emissions of electrical power generation

Plot 12 : Emissions of central heat plants

Plot 13 : Emissions of transportation

Plot 14 : Emissions of industry

Plot 15 : Emissions of residential/commercial.

PLOT 16. Emissions of Nuclear Power Generation

This plot provides the calculated radioactive emissions split up into three waste categories:-

NUCU : Radioactive emissions during reactor operation

NUCP : Radioactive emissions and waste from fuel production and recycling

NUCF : Radio-active emissions and waste from shut-down reactors and fuel plants.

PLOT 17. Accumulation of Nuclear Emissions

Accumulations of the various nuclear emissions (see plot 16) from 1970 on.

```
      PROGRAM EMISS(INPUT,OUTPUT,EMDAT,TAPE4=INPUT,TAPE3=EMDAT,TAPE8=
     1 OUTPUT)
C     * M.P. WORLD - MODEL *
C     ********************
C
C     ENERGY-EMISSION-PLANNING MODEL
C     GOTTWALD INST.MECHANIK A ,HANNOVER
C     ************************************
C
      DIMENSION FELD(20),NDRU(20),REG(18),SCE(18)
      DIMENSION DENERS(5,65),DENERL(5,65),DENERG(5,65),
     1          DENERT(5,65)
      COMMON /DRU/ DEMSF(5,65),DEMLF(5,65),DEMGF(5,65),
     1 DEME(5,65),DEMH(5,65),DEMTR(5,65),DEMI(5,65),DEMRC(5,65)
      COMMON / DR/ DEMS(5,65),DEMT(5,65),DEMR(5,65),NJ,
     1DEMN(5,65),DEMNS(5,65)
      COMMON /NUC/ FRADU,FRADP,FRADF,RADU,RADP,RADF
      COMMON / FG/ FGSO2E,FGSO2H,FGSO2T,FGSO2I,FGSO2R,
     1              GSO2E, GSO2H, GSO2T, GSO2I, GSO2R,
     2             FGAEOE,FGAEOH,FGAEOT,FGAEOI,FGAEOR,
     3              GAEOE, GAEOH, GAEOT, GAEOI, GAEOR
      COMMON /RMOVE/ RCOME,RCO2E,RSO2E,RCHXE,RXNOE,RAEOE,
     2               RCOMH,RCO2H,RSO2H,RCHXH,RXNOH,RAEOH,
     3               RCOMT,RCO2T,RSO2T,RCHXT,RXNOT,RAEOT,
     4               RCOMI,RCO2I,RSO2I,RCHXI,RXNOI,RAEOI,
     5               RCOMR,RCO2R,RSO2R,RCHXR,RXNOR,RAEOR,
     6               SO2RE,SO2RH,SO2RT,SO2RI,SO2RR,
     7               AEORE,AEORH,AEORT,AEORI,AEORR
      COMMON /ENER/ ESFE,ELFE,EGFE,
     2              ESFH,ELFH,EGFH,
     3              ESFT,ELFT,EGFT,
     4              ESFI,ELFI,EGFI,
     5              ESFR,ELFR,EGFR,ENUC
      COMMON /FSOL/ FCOMSE,FCO2SE,FSO2SE,FCHXSE,FXNOSE,FAEOSE,
     2              FCOMSH,FCO2SH,FSO2SH,FCHXSH,FXNOSH,FAEOSH,
     3              FCOMST,FCO2ST,FSO2ST,FCHXST,FXNOST,FAEOST,
     4              FCOMSI,FCO2SI,FSO2SI,FCHXSI,FXNOSI,FAEOSI,
     5              FCOMSR,FCO2SR,FSO2SR,FCHXSR,FXNOSR,FAEOSR
      COMMON /FLIQ/ FCOMLE,FCO2LE,FSO2LE,FCHXLE,FXNOLE,FAEOLE,
     2              FCOMLH,FCO2LH,FSO2LH,FCHXLH,FXNOLH,FAEOLH,
     3              FCOMLT,FCO2LT,FSO2LT,FCHXLT,FXNOLT,FAEOLT,
     4              FCOMLI,FCO2LI,FSO2LI,FCHXLI,FXNOLI,FAEOLI,
     5              FCOMLR,FCO2LR,FSO2LR,FCHXLR,FXNOLR,FAEOLR
      COMMON /FGAS/ FCOMGE,FCO2GE,FSO2GE,FCHXGE,FXNOGE,FAEOGE,
     2              FCOMGH,FCO2GH,FSO2GH,FCHXGH,FXNOGH,FAEOGH,
     3              FCOMGT,FCO2GT,FSO2GT,FCHXGT,FXNOGT,FAEOGT,
     4              FCOMGI,FCO2GI,FSO2GI,FCHXGI,FXNOGI,FAEOGI,
     5              FCOMGR,FCO2GR,FSO2GR,FCHXGR,FXNOGR,FAEOGR
      COMMON / SOL/ COMSE,CO2SE,SO2SE,CHXSE,XNOSE,AEOSE,
     2              COMSH,CO2SH,SO2SH,CHXSH,XNOSH,AEOSH,
     3              COMST,CO2ST,SO2ST,CHXST,XNOST,AEOST,
     4              COMSI,CO2SI,SO2SI,CHXSI,XNOSI,AEOSI,
     5              COMSR,CO2SR,SO2SR,CHXSR,XNOSR,AEOSR
      COMMON / LIQ/ COMLE,CO2LE,SO2LE,CHXLE,XNOLE,AEOLE,
     2              COMLH,CO2LH,SO2LH,CHXLH,XNOLH,AEOLH,
     3              COMLT,CO2LT,SO2LT,CHXLT,XNOLT,AEOLT,
     4              COMLI,CO2LI,SO2LI,CHXLI,XNOLI,AEOLI,
     5              COMLR,CO2LR,SO2LR,CHXLR,XNOLR,AEOLR
      COMMON / GAS/ COMGE,CO2GE,SO2GE,CHXGE,XNOGE,AEOGE,
```

```
     2               COMGH,CO2GH,SO2GH,CHXGH,XNOGH,AEOGH,
     3               COMGT,CO2GT,SO2GT,CHXGT,XNOGT,AEOGT,
     4               COMGI,CO2GI,SO2GI,CHXGI,XNOGI,AEOGI,
     5               COMGR,CO2GR,SO2GR,CHXGR,XNOGR,AEOGR
      COMMON / SUM/ SCOME,SCO2E,SSO2E,SCHXE,SXNOE,SAEOE,
     2               SCOMH,SCO2H,SSO2H,SCHXH,SXNOH,SAEOH,
     3               SCOMT,SCO2T,SSO2T,SCHXT,SXNOT,SAEOT,
     4               SCOMI,SCO2I,SSO2I,SCHXI,SXNOI,SAEOI,
     5               SCOMR,SCO2R,SSO2R,SCHXR,SXNOR,SAEOR,
     6               SCOMS,SCO2S,SSO2S,SCHXS,SXNOS,SAEOS,
     7               SCOML,SCO2L,SSO2L,SCHXL,SXNOL,SAEOL,
     8               SCOMG,SCO2G,SSO2G,SCHXG,SXNOG,SAEOG,
     9               SCOM ,SCO2 ,SSO2 ,SCHX ,SXNO ,SAEO,SGSO2,SGAEO,
     1               SRSO2,SRAEO
      COMMON / TOT/ COMTOT,CO2TOT,SO2TOT,CHXTOT,XNOTOT,AEOTOT,
     2               COMSF ,CO2SF ,SO2SF ,CHXSF ,XNOSF ,AEOSF ,
     3               COMLF ,CO2LF ,SO2LF ,CHXLF ,XNOLF ,AEOLF ,
     4               COMGF ,CO2GF ,SO2GF ,CHXGF ,XNOGF ,AEOGF ,
     5               COME  ,CO2E  ,SO2E  ,CHXE  ,XNOE  ,AEOE  ,
     6               COMH  ,CO2H  ,SO2H  ,CHXH  ,XNOH  ,AEOH  ,
     7               COMT  ,CO2T  ,SO2T  ,CHXT  ,XNOT  ,AEOT  ,
     8               COMI  ,CO2I  ,SO2I  ,CHXI  ,XNOI  ,AEOI  ,
     9               COMR  ,CO2R  ,SO2R  ,CHXR  ,XNOR  ,AEOR
1000  FORMAT(20A4)
2000  FORMAT(1H1,///,1X,20A4)
2001  FORMAT(1X,20A4)
      READ  (4,1000)(FELD(J),J=1,20)
      WRITE(8,2000)(FELD(J),J=1,20)
      READ  (4,1000)(FELD(J),J=1,20)
      WRITE(8, 2001)(FELD(J),J=1,20)
      READ  (4,1000)(FELD(J),J=1,20)
      WRITE(8, 2001)(FELD(J),J=1,20)
      CALL READF
 2032 FORMAT(2F10.1)
      READ(4,2032) WATT,AREA
2012  FORMAT(20I1)
      READ (4,2012) (NDRU(J),J=1,20)
2033  FORMAT(1X,/,1X,F6.2,"MIO KM**2    ",
     1                F6.2,"WATT/M**2",/)
      WRITE(8,2033) AREA,WATT
1001  FORMAT(I5,1X,I1,2X,7E10.3,/,
     1                  9X,7E10.3,/,
     2                  9X,7E10.3)
      CALL  ZERO
       READ(3,1000) (REG(I),I=1,18)
      READ(3,1000) (SCE(I),I=1,18)
      DO 10 I=1,5
      DO 10 J=1,65
20    DENERL(I,J)=0.0
30    DENERG(I,J)=0.0
40    DENERT(I,J)=0.0
       DEMT(I,J)=0.0
42    DEMS(I,J)=0.0
43    DEMR(I,J)=0.0
44    DEME(I,J)=0.0
45    DEMH(I,J)=0.0
46    DEMT(I,J)=0.0
47    DEMI(I,J)=0.0
48    DEMR(I,J)=0.0
```

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49     DEMSF(I,J)=0.0
50     DEMLF(I,J)=0.0
51     DEMGF(I,J)=0.0
52     DEMN(I,J)=0.0
53     DEMNS(I,J)=0.0
10      DENERS(I,J)=0.0
       NEND=0
2002   FORMAT (1X,11F10.2)
2003   FORMAT (1X,"      SCOM      SCO2      SSO2      SCHX      SXNO",
      2 "      SAEO      SRAP      SRAF     SGSO2     SGAEO",
      3//,1X)
       NJ=0
2004   FORMAT(1X,"SOLID FUEL INPUT",/,1X,
      1"1=ESFE 2=ESFH 3=ESFT 4=ESFI 5=ESFR")
2005   FORMAT(1X,"LIQIUD FUEL INPUT",/,1X,
      1"1=ELFE 2=ELFH 3=ELFT 4=ELFI 5=ELFR")
2006   FORMAT(1X,"GASEOUS FUEL INPUT",/,1X,
      1"1=EGFE 2=EGFH 3=EGFT 4=EGFI 5=EGFR")
2007   FORMAT(1X,"NUCLEAR AND TOTAL ENERGY INPUT",/,1X,
      1"1=ENUC 2=EUSE 3=EWAST 4=ETOT         ",/1X,
      2"5=ETOT * 100 / SOLAR IRRADIATION")
2009   FORMAT(1X,"ACCUMULATED EMISSIONS")
2010   FORMAT(1X,"REDUCED EMISSIONS")
2008   FORMAT(1X,
      1"1=CO2 2=SO2 3=CHX 4=NOX 5=AEO")
2016   FORMAT(1X,"EMISSIONS OF ELECTRIC POWER GENERATION")
104    READ(3,1001)          JAHR,NR,ESFE,ESFH,ESFT,ESFI,ESFR,
      2             ELFE,ELFH,ELFT,ELFI,ELFR,
      3             EGFE,EGFH,EGFT,EGFI,EGFR,
      5 ENUC,              EUSE,EWAST,ETOT
       IF (EOF(3) .NE. 0) GO TO 101
       GOTO 102
101    NEND=1
       REWIND 4
       GOTO 103
102    NJ=NJ+1
       CALL CALEMI
       CALL SUMMAT
C      CALL DRUCK
       DENERS(1,NJ)=ESFE
       DENERS(2,NJ)=ESFH
       DENERS(3,NJ)=ESFT
       DENERS(4,NJ)=ESFI
       DENERS(5,NJ)=ESFR
C
C
       DENERL(1,NJ)=ELFE
       DENERL(2,NJ)=ELFH
       DENERL(3,NJ)=ELFT
       DENERL(4,NJ)=ELFI
       DENERL(5,NJ)=ELFR
C
C
       DENERG(1,NJ)=EGFE
       DENERG(2,NJ)=EGFH
       DENERG(3,NJ)=EGFT
       DENERG(4,NJ)=EGFI
       DENERG(5,NJ)=EGFR
C
```

```
C
      DENERT(1,NJ)=ENUC
      DENERT(2,NJ)=EUSE
      DENERT(3,NJ)=EWAST
      DENERT(4,NJ)=ETOT
      DENERT(5,NJ)=95.8*ETOT/(WATT*AREA)
2041  FORMAT(1H1,18A4,/,1X,18A4)
2040  FORMAT(1X,"ENERGY UNITS ARE BILLIONS",
     1          " OF METRIC TONS OF COAL EQUIVALENT")
2042  FORMAT(1X,"EMISSIONS UNITS ARE 10**6 TONS,ONLY CO2 10**9 TONS")
2043  FORMAT(1X,"EMISSION UNITS ARE MCI")
2044  FORMAT(1X,"EMISSIONS IN 10**  TONS,COSTS IN 10**9 US DOLLARS")
2045  FORMAT(1X,"1=TRSO2 2=TRAEO 3=GSO2 4=GAEO")
103   IF(NEND.EQ.0) GOTO 104
       DO 551 IPT=1,17
       IF(NDRU(IPT).NE.1)GO TO 551
       WRITE(8,2041) (REG(I),I=1,18),(SCE(J),J=1,18)
       GOTO(552,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70),IPT
552      WRITE(8,2004)
      WRITE(8,2040)
      CALL BILD(DENERS)
       GO TO 551
55      WRITE(8,2005)
      WRITE(8,2040)
       CALL BILD(DENERL)
       GOTO551
56      WRITE(8,2006)
      WRITE(8,2040)
      CALL BILD(DENERG)
       GOTO 551
57      WRITE(8,2007)
      WRITE(8,2040)
      CALL BILD(DENERT)
       GOTO 551
58      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2024)
2024  FORMAT(1X,"TOTALS OF EMISSONS / YEAR")
      CALL BILD(DEMT)
       GOTO 551
59      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2009)
      CALL BILD(DEMS)
       GOTO 551
60      WRITE(8,2045)
      WRITE(8,2044)
      WRITE(8,2010)
       CALL BILD(DEMR)
       GOTO 551
61      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2013)
2013  FORMAT(1X,"EMISSIONS OF SOLID FUEL")
      CALL BILD(DEMSF)
       GOTO 551
62      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2014)
```

```
2014  FORMAT(1X,"EMISSIONS OF LIQUID FUEL")
       CALL BILD(DEMLF)
       GOTO 551
63      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2015)
2015  FORMAT(1X,"EMISSIONS OF GASEOUS FUEL")
      CALL BILD(DEMGF)
       GOTO 551
64      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2016)
      CALL BILD(DEME)
       GOTO 551
65      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2017)
2017  FORMAT(1X,"EMISSIONS OF CENTRAL HEAT PLANTS")
      CALL BILD(DEMH)
       GOTO551
66      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2018)
2018  FORMAT(1X,"EMISSIONS OF TRANSPORTATION")
      CALL BILD(DEMTR)
       GOTO 551
67      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2019)
2019  FORMAT(1X,"EMISSIONS OF INDUSTRY")
      CALL BILD(DEMI)
       GOTO 551
68      WRITE(8,2042)
      WRITE(8,2008)
      WRITE(8,2020)
2020  FORMAT(1X,"EMISSIONS OF RESIDENTIAL/COMMERCIAL")
      CALL BILD(DEMRC)
       GOTO 551
69      WRITE(8,2021)
      WRITE(8,2043)
      WRITE(8,2022)
2021  FORMAT(1X,"1=NUCU 2=NUCP 3=NUCF")
2022  FORMAT(    1X,"EMISSIONS OF NUCLEAR POWER GENERATION")
      CALL BILD(DEMN)
       GOTO 551
70      WRITE(8,2021)
      WRITE(8,2043)
      WRITE(8,2023)
2023  FORMAT(1X,"ACCUMULATED OF NUCLEAR EMISSIONS")
      CALL BILD(DEMNS)
551    CONTINUE
71    CONTINUE
      END
```

```
      SUBROUTINE BILD (EING)
      DIMENSION FELD(67),EING(5,65),Z(67),CL(10)
      REAL    MIN,MAX
      DATA CL/"1","2","3" ,"4","5","6","7","8","9","0"/
      DATA STR/"I"/,Q/"-"/,AL/"X"/,BL/" "/
      DO 5 J=1,67
    5 FELD(J)=BL
      MAX=EING(1,1)
      DO 2 J=1,65
      DO 2 I=1,5
      X=MAX-EING(I,J)
      IF (X.LT.0) MAX=EING(I,J)
    2 CONTINUE
      MIN=EING(1,1)
      DO 3 J=1,65
      DO 3 I=1,5
      X=MIN-EING(I,J)
      IF (X.GT.0) MIN=EING(I,J)
    3 CONTINUE
      IF(MAX .NE. MIN ) GO TO 15
      MAX = MAX + 1.0
      MIN = MIN - 1.0
 15   DIFF=MAX-MIN
      SPR=DIFF/60.
      Z(1)=MAX
      DO 4 K=2,61
      Z(K)=Z(K-1)-SPR
    4 CONTINUE
      Y=SPR/2.
       DO 13 K=1,61
       DO 133 I1=1,67
133    FELD(I1)=BL
       DO 131 I=1,5
      M=2
      DO 131 J=1,65
      M=M+1
       FELD(1)=Z(K)
      A =EING(I,J)-Z(K)
      IF (A.LT.-Y) GO TO 131
      IF (A.GT.+Y) GO TO 131
      FELD(M)=CL(I)
131    CONTINUE
13     WRITE(8,30)(FELD(I1),I1=1,67)
   30 FORMAT(1X,E11.4,1X,66A1)
      WRITE(8,31)
   31 FORMAT(5X,
     1"      1970    75    80    85    90    95 2000    05    10    15    20    ",
     X  "25    30    35")
       RETURN
       END
```

```
      SUBROUTINE READF
      COMMON /NUC/ FRADU,FRADP,FRADF,RADU,RADP,RADF
      COMMON / FG/ FGSO2E,FGSO2H,FGSO2T,FGSO2I,FGSO2R,
     2              GSO2E, GSO2H, GSO2T, GSO2I, GSO2R,
     3             FGAEOE,FGAEOH,FGAEOT,FGAEOI,FGAEOR,
     4              GAEOE, GAEOH, GAEOT, GAEOI, GAEOR
      COMMON /FSOL/ FCOMSE,FCO2SE,FSO2SE,FCHXSE,FXNOSE,FAEOSE,
     2              FCOMSH,FCO2SH,FSO2SH,FCHXSH,FXNOSH,FAEOSH,
     3              FCOMST,FCO2ST,FSO2ST,FCHXST,FXNOST,FAEOST,
     4              FCOMSI,FCO2SI,FSO2SI,FCHXSI,FXNOSI,FAEOSI,
     5              FCOMSR,FCO2SR,FSO2SR,FCHXSR,FXNOSR,FAEOSR
      COMMON /FLIQ/ FCOMLE,FCO2LE,FSO2LE,FCHXLE,FXNOLE,FAEOLE,
     2              FCOMLH,FCO2LH,FSO2LH,FCHXLH,FXNOLH,FAEOLH,
     3              FCOMLT,FCO2LT,FSO2LT,FCHXLT,FXNOLT,FAEOLT,
     4              FCOMLI,FCO2LI,FSO2LI,FCHXLI,FXNOLI,FAEOLI,
     5              FCOMLR,FCO2LR,FSO2LR,FCHXLR,FXNOLR,FAEOLR
      COMMON /FGAS/ FCOMGE,FCO2GE,FSO2GE,FCHXGE,FXNOGE,FAEOGE,
     2              FCOMGH,FCO2GH,FSO2GH,FCHXGH,FXNOGH,FAEOGH,
     3              FCOMGT,FCO2GT,FSO2GT,FCHXGT,FXNOGT,FAEOGT,
     4              FCOMGI,FCO2GI,FSO2GI,FCHXGI,FXNOGI,FAEOGI,
     5              FCOMGR,FCO2GR,FSO2GR,FCHXGR,FXNOGR,FAEOGR
      COMMON /RMOVE/ RCOME,RCO2E,RSO2E,RCHXE,RXNOE,RAEOE,
     2               RCOMH,RCO2H,RSO2H,RCHXH,RXNOH,RAEOH,
     3               RCOMT,RCO2T,RSO2T,RCHXT,RXNOT,RAEOT,
     4               RCOMI,RCO2I,RSO2I,RCHXI,RXNOI,RAEOI,
     5               RCOMR,RCO2R,RSO2R,RCHXR,RXNOR,RAEOR,
     6               SO2RE,SO2RH,SO2RT,SO2RI,SO2RR,
     7               AEORE,AEORH,AEORT,AEORI,AEORR
1000  FORMAT(6F7.3)
2000  FORMAT(1X,1X,1X,15X,"   CO      CO2      SO2       CH       NO "
     1,"    AEO",
     1 /,1X,       14HELECTRIC       ,6F8.3,
     2 /,1X,       14HHEAT PLANT     ,6F8.3,
     3 /,1X,       14HTRANSPORT.     ,6F8.3,
     4 /,1X,       14HINDUSTRY       ,6F8.3,
     5 /,1X,       14HRES./COM.      ,6F8.3,       1X,1X)
2001  FORMAT(/,1X,"EMISSIONS OF SOLID FUEL",
     1       /,1X,"**************************")
2002  FORMAT(/,1X,"EMISSIONS OF LIQUID FUEL",
     1       /,1X,"***************************")
2003  FORMAT(/,1X,"EMISSIONS OF GASEOUS FUEL",
     1       /,1X,"****************************")
      READ(4,1000) RCOME,RCO2E,RSO2E,RCHXE,RXNOE,RAEOE
      READ(4,1000) RCOMH,RCO2H,RSO2H,RCHXH,RXNOH,RAEOH
      READ(4,1000) RCOMT,RCO2T,RSO2T,RCHXT,RXNOT,RAEOT
      READ(4,1000) RCOMI,RCO2I,RSO2I,RCHXI,RXNOI,RAEOI
      READ(4,1000) RCOMR,RCO2R,RSO2R,RCHXR,RXNOR,RAEOR
      WRITE(8,2004)
2004  FORMAT(/,1X,"REDUCTION FACTORS",
     1       /,1X,"******************")
      WRITE(8,2000)RCOME,RCO2E,RSO2E,RCHXE,RXNOE,RAEOE,
     X             RCOMH,RCO2H,RSO2H,RCHXH,RXNOH,RAEOH,
     X             RCOMT,RCO2T,RSO2T,RCHXT,RXNOT,RAEOT,
     X             RCOMI,RCO2I,RSO2I,RCHXI,RXNOI,RAEOI,
     X             RCOMR,RCO2R,RSO2R,RCHXR,RXNOR,RAEOR
      READ(4,1000) FGSO2E,FGSO2H,FGSO2T,FGSO2I,FGSO2R
      READ(4,1000) FGAEOE,FGAEOH,FGAEOT,FGAEOI,FGAEOR
2005  FORMAT(/,1X,"REDUCTION COSTS",
     1       /,1X,"****************")
```

```
2006  FORMAT(1X,1X,1X,17X,     "SO2      AEO",
     1 /,1X,14HELECTRIC       ,2F8.3,
     2 /,1X,      14HHEAT PLANT     ,2F8.3,
     3/,1X,       14HTRANSPORT.     ,2F8.3,
     4 /,1X,      14HINDUSTRY       ,2F8.3,
     5 /,1X,      14HRES./COM.      ,2F8.3,       1X,1X)
      WRITE(8,2005)
      WRITE(8,2006) FGSO2E,FGAEOE,
     2              FGSO2H,FGAEOH,
     3              FGSO2T,FGAEOT,
     4              FGSO2I,FGAEOI,
     5              FGSO2R,FGAEOR
C
      READ(4,1000) FCOMSE,FCO2SE,FSO2SE,FCHXSE,FXNOSE,FAEOSE
      READ(4,1000) FCOMSH,FCO2SH,FSO2SH,FCHXSH,FXNOSH,FAEOSH
      READ(4,1000) FCOMST,FCO2ST,FSO2ST,FCHXST,FXNOST,FAEOST
      READ(4,1000) FCOMSI,FCO2SI,FSO2SI,FCHXSI,FXNOSI,FAEOSI
      READ(4,1000) FCOMSR,FCO2SR,FSO2SR,FCHXSR,FXNOSR,FAEOSR
C
      READ(4,1000) FCOMLE,FCO2LE,FSO2LE,FCHXLE,FXNOLE,FAEOLE
      READ(4,1000) FCOMLH,FCO2LH,FSO2LH,FCHXLH,FXNOLH,FAEOLH
      READ(4,1000) FCOMLT,FCO2LT,FSO2LT,FCHXLT,FXNOLT,FAEOLT
      READ(4,1000) FCOMLI,FCO2LI,FSO2LI,FCHXLI,FXNOLI,FAEOLI
      READ(4,1000) FCOMLR,FCO2LR,FSO2LR,FCHXLR,FXNOLR,FAEOLR
C
      READ(4,1000) FCOMGE,FCO2GE,FSO2GE,FCHXGE,FXNOGE,FAEOGE
      READ(4,1000) FCOMGH,FCO2GH,FSO2GH,FCHXGH,FXNOGH,FAEOGH
      READ(4,1000) FCOMGT,FCO2GT,FSO2GT,FCHXGT,FXNOGT,FAEOGT
      READ(4,1000) FCOMGI,FCO2GI,FSO2GI,FCHXGI,FXNOGI,FAEOGI
      READ(4,1000) FCOMGR,FCO2GR,FSO2GR,FCHXGR,FXNOGR,FAEOGR
C
      WRITE(8,2001)
      WRITE(8,2000)FCOMSE,FCO2SE,FSO2SE,FCHXSE,FXNOSE,FAEOSE,
     2             FCOMSH,FCO2SH,FSO2SH,FCHXSH,FXNOSH,FAEOSH,
     3             FCOMST,FCO2ST,FSO2ST,FCHXST,FXNOST,FAEOST,
     4             FCOMSI,FCO2SI,FSO2SI,FCHXSI,FXNOSI,FAEOSI,
     5             FCOMSR,FCO2SR,FSO2SR,FCHXSR,FXNOSR,FAEOSR
C
      WRITE(8,2002)
      WRITE(8,2000)FCOMLE,FCO2LE,FSO2LE,FCHXLE,FXNOLE,FAEOLE,
     2             FCOMLH,FCO2LH,FSO2LH,FCHXLH,FXNOLH,FAEOLH,
     3             FCOMLT,FCO2LT,FSO2LT,FCHXLT,FXNOLT,FAEOLT,
     4             FCOMLI,FCO2LI,FSO2LI,FCHXLI,FXNOLI,FAEOLI,
     5             FCOMLR,FCO2LR,FSO2LR,FCHXLR,FXNOLR,FAEOLR
C
      WRITE(8,2003)
      WRITE(8,2000)FCOMGE,FCO2GE,FSO2GE,FCHXGE,FXNOGE,FAEOGE,
     2             FCOMGH,FCO2GH,FSO2GH,FCHXGH,FXNOGH,FAEOGH,
     3             FCOMGT,FCO2GT,FSO2GT,FCHXGT,FXNOGT,FAEOGT,
     4             FCOMGI,FCO2GI,FSO2GI,FCHXGI,FXNOGI,FAEOGI,
     5             FCOMGR,FCO2GR,FSO2GR,FCHXGR,FXNOGR,FAEOGR
      WRITE(8,2008)
2007  FORMAT(/1X,9X,"      FRADU      FRADP      FRADF",1X,1X,
     1  /,10X,3F11.3,//,1X)
2008  FORMAT(/," NUCLEAR EMISSIONS",
     1          /1X,"******************")
      READ(4,1000)FRADU,FRADP,FRADF
      WRITE (8,2007) FRADU,FRADP,FRADF
C
```

```
RETURN
END
```

```
      SUBROUTINE CALEMI
      COMMON /RMOVE/ RCOME,RCO2E,RSO2E,RCHXE,RXNOE,RAEOE,
     2               RCOMH,RCO2H,RSO2H,RCHXH,RXNOH,RAEOH,
     3               RCOMT,RCO2T,RSO2T,RCHXT,RXNOT,RAEOT,
     4               RCOMI,RCO2I,RSO2I,RCHXI,RXNOI,RAEOI,
     5               RCOMR,RCO2R,RSO2R,RCHXR,RXNOR,RAEOR,
     6SO2RE,SO2RH,SO2RT,SO2RI,SO2RR,
     7AEORE,AEORH,AEORT,AEORI,AEORR
      COMMON/DRU/DEMSF(5,65),DEMLF(5,65),DEMGF(5,65),
     1 DEME(5,65),DEMH(5,65),DEMTR(5,65),DEMI(5,65),DEMRC(5,65)
      COMMON / DR/ DEMS(5,65),DEMT(5,65),DEMR(5,65),NJ,
     2             DEMN(5,65),DEMNS(5,65)
      COMMON /NUC/ FRADU,FRADP,FRADF,RADU,RADP,RADF
      COMMON /ENER/ ESFE,ELFE,EGFE,
     2              ESFH,ELFH,EGFH,
     3              ESFT,ELFT,EGFT,
     4              ESFI,ELFI,EGFI,
     5              ESFR,ELFR,EGFR,ENUC
      COMMON /FSOL/ FCOMSE,FCO2SE,FSO2SE,FCHXSE,FXNOSE,FAEOSE,
     2              FCOMSH,FCO2SH,FSO2SH,FCHXSH,FXNOSH,FAEOSH,
     3              FCOMST,FCO2ST,FSO2ST,FCHXST,FXNOST,FAEOST,
     4              FCOMSI,FCO2SI,FSO2SI,FCHXSI,FXNOSI,FAEOSI,
     5              FCOMSR,FCO2SR,FSO2SR,FCHXSR,FXNOSR,FAEOSR
      COMMON /FLIQ/ FCOMLE,FCO2LE,FSO2LE,FCHXLE,FXNOLE,FAEOLE,
     2              FCOMLH,FCO2LH,FSO2LH,FCHXLH,FXNOLH,FAEOLH,
     3              FCOMLT,FCO2LT,FSO2LT,FCHXLT,FXNOLT,FAEOLT,
     4              FCOMLI,FCO2LI,FSO2LI,FCHXLI,FXNOLI,FAEOLI,
     5              FCOMLR,FCO2LR,FSO2LR,FCHXLR,FXNOLR,FAEOLR
      COMMON /FGAS/ FCOMGE,FCO2GE,FSO2GE,FCHXGE,FXNOGE,FAEOGE,
     2              FCOMGH,FCO2GH,FSO2GH,FCHXGH,FXNOGH,FAEOGH,
     3              FCOMGT,FCO2GT,FSO2GT,FCHXGT,FXNOGT,FAEOGT,
     4              FCOMGI,FCO2GI,FSO2GI,FCHXGI,FXNOGI,FAEOGI,
     5              FCOMGR,FCO2GR,FSO2GR,FCHXGR,FXNOGR,FAEOGR
      COMMON / SOL/ COMSE,CO2SE,SO2SE,CHXSE,XNOSE,AEOSE,
     2              COMSH,CO2SH,SO2SH,CHXSH,XNOSH,AEOSH,
     3              COMST,CO2ST,SO2ST,CHXST,XNOST,AEOST,
     4              COMSI,CO2SI,SO2SI,CHXSI,XNOSI,AEOSI,
     5              COMSR,CO2SR,SO2SR,CHXSR,XNOSR,AEOSR
      COMMON / LIQ/ COMLE,CO2LE,SO2LE,CHXLE,XNOLE,AEOLE,
     2              COMLH,CO2LH,SO2LH,CHXLH,XNOLH,AEOLH,
     3              COMLT,CO2LT,SO2LT,CHXLT,XNOLT,AEOLT,
     4              COMLI,CO2LI,SO2LI,CHXLI,XNOLI,AEOLI,
     5              COMLR,CO2LR,SO2LR,CHXLR,XNOLR,AEOLR
      COMMON / GAS/ COMGE,CO2GE,SO2GE,CHXGE,XNOGE,AEOGE,
     2              COMGH,CO2GH,SO2GH,CHXGH,XNOGH,AEOGH,
     3              COMGT,CO2GT,SO2GT,CHXGT,XNOGT,AEOGT,
     4              COMGI,CO2GI,SO2GI,CHXGI,XNOGI,AEOGI,
     5              COMGR,CO2GR,SO2GR,CHXGR,XNOGR,AEOGR
      COMMON / TOT/ COMTOT,CO2TOT,SO2TOT,CHXTOT,XNOTOT,AEOTOT,
     2              COMSF ,CO2SF ,SO2SF ,CHXSF ,XNOSF ,AEOSF ,
     3              COMLF ,CO2LF ,SO2LF ,CHXLF ,XNOLF ,AEOLF ,
     4              COMGF ,CO2GF ,SO2GF ,CHXGF ,XNOGF ,AEOGF ,
     5              COME  ,CO2E  ,SO2E  ,CHXE  ,XNOE  ,AEOE  ,
     6              COMH  ,CO2H  ,SO2H  ,CHXH  ,XNOH  ,AEOH  ,
     7              COMT  ,CO2T  ,SO2T  ,CHXT  ,XNOT  ,AEOT  ,
     8              COMI  ,CO2I  ,SO2I  ,CHXI  ,XNOI  ,AEOI  ,
     9              COMR  ,CO2R  ,SO2R  ,CHXR  ,XNOR  ,AEOR
C
C     CALCULATION OF EMISSIONS
```

```
C
C       SOLID FUEL
C
C       ELECTRIC POWER GENERATION
        COMSE = ESFE * FCOMSE
        CO2SE = ESFE * FCO2SE
        SO2SE = ESFE * FSO2SE
        CHXSE = ESFE * FCHXSE
        AEOSE = ESFE * FAEOSE
C
C       HEAT PLANT
        COMSH = ESFH * FCOMSH
        CO2SH = ESFH * FCO2SH
        SO2SH = ESFH * FSO2SH
        CHXSH = ESFH * FCHXSH
        XNOSH = ESFH * FXNOSH
        AEOSH = ESFH * FAEOSH
C
C       TRANSPORTATION
        COMST = ESFT * FCOMST
        CO2ST = ESFT * FCO2ST
        SO2ST = ESFT * FSO2ST
        CHXST = ESFT * FCHXST
        XNOST = ESFT * FXNOST
        AEOST = ESFT * FAEOST
C
C       INDUSTRY
        COMSI = ESFI * FCOMSI
        CO2SI = ESFI * FCO2SI
        SO2SI = ESFI * FSO2SI
        CHXSI = ESFI * FCHXSI
        XNOSI = ESFI * FXNOSI
        AEOSI = ESFI * FAEOSI
C
C       RESIDENTIAL/COMMERCIAL
        COMSR = ESFR * FCOMSR
        CO2SR = ESFR * FCO2SR
        SO2SR = ESFR * FSO2SR
        CHXSR = ESFR * FCHXSR
        XNOSR = ESFR * FXNOSR
        AEOSR = ESFR * FAEOSR
C
C       TOTAL EMISSIONS
        COMSF =(COMSE+COMSH+COMST+COMSI+COMSR)
        CO2SF =(CO2SE+CO2SH+CO2ST+CO2SI+CO2SR)
        SO2SF =(SO2SE+SO2SH+SO2ST+SO2SI+SO2SR)
        CHXSF =(CHXSE+CHXSH+CHXST+CHXSI+CHXSR)
        XNOSF =(XNOSE+XNOSH+XNOST+XNOSI+XNOSR)
        AEOSF =(AEOSE+AEOSH+AEOST+AEOSI+AEOSR)
C
C       LIQUID FUEL
C
C       ELECTRIC POWER GENERATION
        COMLE = ELFE * FCOMLE
        CO2LE = ELFE * FCO2LE
        SO2LE = ELFE * FSO2LE
        CHXLE = ELFE * FCHXLE
        XNOLE = ELFE * FXNOLE
        AEOLE = ELFE * FAEOLE
```

```
C
C       HEAT PLANT
        COMLH = ELFH * FCOMLH
        COMLH = ELFH * FCOMLH
        CO2LH = ELFH * FCO2LH
        SO2LH = ELFH * FSO2LH
        CHXLH = ELFH * FCHXLH
        XNOLH = ELFH * FXNOLH
        AEOLH = ELFH * FAEOLH
C
C       TRANSPORTATION
        COMLT = ELFT * FCOMLT
        CO2LT = ELFT * FCO2LT
        SO2LT = ELFT * FSO2LT
        CHXLT = ELFT * FCHXLT
        XNOLT = ELFT * FXNOLT
        AEOLT = ELFT * FAEOLT
C
C       INDUSTRY
        COMLI = ELFI * FCOMLI
        CO2LI = ELFI * FCO2LI
        SOILI = ELFI * FSO2LI
        CHXLI = ELFI * FCHXLI
        XNOLI = ELFI * FXNOLI
        AEOLI = ELFI * FAEOLI
C
C       RESIDENTIAL/COMMERCIAL
        COMLR = ELFR * FCOMLR
        CO2LR = ELFR * FCO2LR
        SO2LR = ELFR * FSO2LR
        CHXLR = ELFR * FCHXLR
        XNOLR = ELFR * FXNOLR
        AEOLR = ELFR * FAEOLR
C
C       TOTAL EMISSIONS
        COMLF = (COMLE+COMLH+COMLT+COMLI+COMLR)
        CO2LF = (CO2LE+CO2LH+CO2LT+CO2LI+CO2LR)
        SO2LF =(SO2LE+SO2LH+SO2LT+SO2LI+SO2LR )
        CHXLF =(CHXLE+CHXLH+CHXLT+CHXLI+CHXLR )
        XNOLF =(XNOLE+XNOLH+XNOLT+XNOLI+XNOLR )
        AEOLF =(AEOLE+AEOLH+AEOLT+AEOLI+AEOLR )
C
C       GASEOUS FUEL
C
C       ELECTRIC POWER GENERATION
        COMGE = EGFE * FCOMGE
        CO2GE = EGFE * FCO2GE
        SO2GE = EGFE * FSO2GE
        CHXGE = EGFE * FCHXGE
        XNOGE = EGFE * FXNOGE
        AEOGE = EGFE * FAEOGE
C
C       HEAT PLANT
        COMGH = EGFH * FCOMGH
        CO2GH = EGFH * FCO2GH
        SO2GH = EGFH * FSO2GH
        CHXGH = EGFH * FCHXGH
        XNOGH = EGFH * FXNOGH
        AEOGH = EGFH * FAEOGH
```

```
C
C       TRANSPORTATION
        COMGT = EGFT * FCOMGT
        CO2GT = EGFT * FCO2GT
        SO2GT = EGFT * FSO2GT
        CHXGT = EGFT * FCHXGT
        XNOGT = EGFT * FXNOGT
        AEOGT = EGFT * FAEOGT
C
C       INDUSTRY
        COMGI = EGFI * FCOMGI
        CO2GI = EGFI * FCO2GI
        SO2GI = EGFI * FSO2GI
        CHXGI = EGFI * FCHXGI
        XNOGI = EGFI * FNOXGI
        AEOGI = EGFI * FAEOGI
C
C       RESIDENTIAL/COMMERCIAL
        COMGR = EGFR * FCOMGR
        CO2GR = EGFR * FCO2GR
        SO2GR = EGFR * FSO2GR
        CHXGR = EGFR * FCHXGR
        XNOGR = EGFR * FXNOGR
        AEOGR = EGFR * FAEOGR
C
C       TOTAL EMISSIONS
        COMGF =(COMGE+COMGH+COMGT+COMGI+COMGR)
        CO2GF =(CO2GE+CO2GH+CO2GT+CO2GI+CO2GR)
        SO2GF =(SO2GE+SO2GH+SO2GT+SO2GI+SO2GR)
        CHXGF =(CHXGE+CHXGH+CHXGT+CHXGI+CHXGR)
        XNOGF =(XNOGE+XNOGH+XNOGT+XNOGI+XNOGR)
        AEOGF =(AEOGE+AEOGH+AEOGT+AEOGI+AEOGR)
C
C       TOTAL EMISSIONS
C
C       ELECTRIC
        COME = COMSE + COMLE + COMGE
        CO2E = CO2SE + CO2LE + CO2GE
        SO2E = SO2SE + SO2LE + SO2GE
        CHXE = CHXSE + CHXLE + CHXGE
        XNOE = XNOSE + XNOLE + XNOGE
        AEOE = AEOSE + AEOLE + AEOGE
C
C       HEAT PLANT
        COMH = COMSH + COMLH + COMGH
        CO2H = CO2SH + CO2LH + CO2GH
        SO2H = SO2SH + SO2LH + SO2GH
        CHXH = CHXSH + CHXLH + CHXGH
        XNOH = XNOSH + XNOLH + XNOGH
        AEOH = AEOSH + AEOLH + AEOGH
C
C       TRANSPORTATION
        COMT = COMST + COMLT + COMGT
        CO2T = CO2ST + CO2LT + CO2GT
        SO2T = SO2ST + SO2LT + SO2GT
        CHXT = CHXST + CHXLT + CHXGT
        XNOT = XNOST + XNOLT + XNOGT
        AEOT = AEOST + AEOLT + AEOGT
C
```

```
C       INDUSTRY
        COMI = COMSI + COMLI + COMGI
        CO2I = CO2SI + CO2LI + CO2GI
        SO2I = SO2SI + SO2LI + SO2GI
        CHXI = CHXSI + CHXLI + CHXGI
        XNOI = XNOSI + XNOLI + XNOGI
        AEOI = AEOSI + AEOLI + AEOGI
C
C       RESIDENTIAL/COMMERCIAL
        COMR = COMSR + COMLR + COMGR
        CO2R = CO2SR + CO2LR + CO2GR
        SO2R = SO2SR + SO2LR + SO2GR
        CHXR = CHXSR + CHXLR + CHXGR
        XNOR = XNOSR + XNOLR + XNOGR
        AEOR = AEOSR + AEOLR + AEOGR
C
C       TOTAL EMISSIONS
        COMTOT =(COME + COMH + COMT + COMI + COMR)
        CO2TOT =(CO2E + CO2H + CO2T + CO2I + CO2R)
        SO2TOT =(SO2E + SO2H + SO2T + SO2I + SO2R)
        CHXTOT =(CHXE + CHXH + CHXT + CHXI + CHXR)
        XNOTOT =(XNOE + XNOH + XNOT + XNOI + XNOR)
        AEOTOT =(AEOE + AEOH + AEOT + AEOI + AEOR)
C
C
        RADU  = ENUC * FRADU
        RADP  = ENUC * FRADP
         RADF  = ENUC * FRADF
C
C       REDUCTION OF EMISSION
        SO2RE=SO2E*(1-RSO2E)
        SO2RH=SO2H*(1-RSO2H)
        SO2RT=SO2T*(1-RSO2T)
        SO2RI=SO2I*(1-RSO2I)
        SO2RR=SO2R*(1-RSO2R)
C
C
        AEORE=AEOE*(1-RAEOE)
        AEORH=AEOH*(1-RAEOH)
        AEORT=AEOT*(1-RAEOT)
        AEORI=AEOI*(1-RAEOI)
        AEORR=AEOR*(1-RAEOR)
C
C
        DEMSF(1,NJ)=CO2SF
        DEMSF(2,NJ)=SO2SF
        DEMSF(3,NJ)=CHXSF
        DEMSF(4,NJ)=XNOSF
        DEMSF(5,NJ)=AEOSF
C
C
        DEMLF(1,NJ)=CO2LF
        DEMLF(2,NJ)=SO2LF
        DEMLF(3,NJ)=CHXLF
        DEMLF(4,NJ)=XNOLF
        DEMLF(5,NJ)=AEOLF
C
C
        DEMGF(1,NJ)=CO2GF
```

```
      DEMGF(2,NJ)=SO2GF
      DEMGF(3,NJ)=CHXGF
      DEMGF(4,NJ)=XNOGF
      DEMGF(5,NJ)=AEOGF
C
C
      DEME(1,NJ)=CO2E
      DEME(2,NJ)=SO2E
      DEME(3,NJ)=CHXE
      DEME(4,NJ)=XNOE
      DEME(5,NJ)=AEOE
C
C
      DEMH(1,NJ)=CO2H
      DEMH(2,NJ)=SO2H
      DEMH(3,NJ)=CHXH
      DEMH(4,NJ)=XNOH
      DEMH(5,NJ)=AEOH
C
C
      DEMTR(1,NJ)=CO2T
      DEMTR(2,NJ)=SO2T
      DEMTR(3,NJ)=CHXT
      DEMTR(4,NJ)=XNOT
      DEMTR(5,NJ)=AEOT
C
C
      DEMI(1,NJ)=CO2I
      DEMI(2,NJ)=SO2I
      DEMI(3,NJ)=CHXI
      DEMI(4,NJ)=XNOI
      DEMI(5,NJ)=AEOI
C
C
      DEMRC(1,NJ)=CO2R
      DEMRC(2,NJ)=SO2R
      DEMRC(3,NJ)=CHXR
      DEMRC(4,NJ)=XNOR
      DEMRC(5,NJ)=AEOR
      RETURN
      END
```

```
      SUBROUTINE SUMMAT
      COMMON / DR/ DEMS(5,65),DEMT(5,65),DEMR(5,65),NJ,
     2DEMN(5,65),DEMNS(5,65)
      COMMON /NUC/ FRADU,FRADP,FRADF,RADU,RADP,RADF
      COMMON / FG/ FGSO2E,FGSO2H,FGSO2T,FGSO2I,FGSO2R,
     2              GSO2E, GSO2H, GSO2T, GSO2I, GSO2R,
     3             FGAEOE,FGAEOH,FGAEOT,FGAEOI,FGAEOR,
     4              GAEOE, GAEOH, GAEOT, GAEOI, GAEOR
      COMMON / SUM/ SCOME,SCO2E,SSO2E,SCHXE,SXNOE,SAEOE,
     2              SCOMH,SCO2H,SSO2H,SCHXH,SXNOH,SAEOH,
     3              SCOMT,SCO2T,SSO2T,SCHXT,SXNOT,SAEOT,
     4              SCOMI,SCO2I,SSO2I,SCHXI,SXNOI,SAEOI,
     5              SCOMR,SCO2R,SSO2R,SCHXR,SXNOR,SAEOR,
     6              SCOMS,SCO2S,SSO2S,SCHXS,SXNOS,SAEOS,
     7              SCOML,SCO2L,SSO2L,SCHXL,SXNOL,SAEOL,
     8              SCOMG,SCO2G,SSO2G,SCHXG,SXNOG,SAEOG,
     9              SCOM ,SCO2 ,SSO2 ,SCHX ,SXNO ,SAEO,SGSO2,SGAEO,
     1              SRSO2,SRAEO
      COMMON / TOT/ COMTOT,CO2TOT,SO2TOT,CHXTOT,XNOTOT,AEOTOT,
     2              COMSF ,CO2SF ,SO2SF ,CHXSF ,XNOSF ,AEOSF ,
     3              COMLF ,CO2LF ,SO2LF ,CHXLF ,XNOLF ,AEOLF ,
     4              COMGF ,CO2GF ,SO2GF ,CHXGF ,XNOGF ,AEOGF ,
     5              COME  ,CO2E  ,SO2E  ,CHXE  ,XNOE  ,AEOE  ,
     6              COMH  ,CO2H  ,SO2H  ,CHXH  ,XNOH  ,AEOH  ,
     7              COMT  ,CO2T  ,SO2T  ,CHXT  ,XNOT  ,AEOT  ,
     8              COMI  ,CO2I  ,SO2I  ,CHXI  ,XNOI  ,AEOI  ,
     9              COMR  ,CO2R  ,SO2R  ,CHXR  ,XNOR  ,AEOR
      COMMON /RMOVE/ RCOME,RSOMH,RSOMT,RCOMI,RCOMR,
     2               RCO2E,RCO2H,RCO2T,RCO2I,RCO2R,
     3               RSO2E,RSO2H,RSO2T,RSO2I,RSO2R,
     4               RCHXE,RCHXH,RCHXT,RCHXI,RCHXR,
     5               RXNOE,RXNOH,RXNOT,RCNOI,RCNOR,
     6               RAEOE,RAEOH,RAEOT,RAEOI,RAEOR,
     7               SO2RE,SO2RH,SO2RT,SO2RI,SO2RR,
     8               AEORE,AEORH,AEORT,AEORI,AEORR
C
C     SUMMATION DER EMISSIONEN
C
C     NACH TECHNOLOGIEN
C
C     ELECTRIC
      SCOME = SCOME + COME
      SCO2E = SCO2E + CO2E
      SSO2E = SSO2E + SO2E
      SCHXE = SCHXE + CHXE
      SXNOE = SXNOE + XNOE
      SAEOE = SAEOE + AEOE
C
C     HEAT PLANT
      SCOMH = SCOMH + COMH
      SCO2H = SCO2H + CO2H
      SSO2H = SSO2H + SO2H
      SCHXH = SCHXH + CHXH
      SXNOH = SXNOH + XNOH
      SAEOH = SAEOH + AEOH
C
C     TRASPORTATION
      SCOMT = SCOMT + COMT
      SCO2T = SCO2T + CO2T
```

```
      SSO2T = SSO2T + SO2T
      SCHXT = SCHXT + CHXT
      SXNOT = SXNOT + XNOT
      SAEOT = SAEOT + AEOT
C
C     INDUSTRY
      SCOMI = SCOMI + COMI
      SCO2I = SCO2I + CO2I
      SSO2I = SSO2I + SO2I
      SCHXI = SCHXI + CHXI
      SXNOI = SXNOI + XNOI
      SAEOI = SAEOI + AEOI
C
C     RESIDENTIAL/COMMERCIAL
      SCOMR = SCOMR + COMR
      SCO2R = SCO2R + CO2R
      SSO2R = SSO2R + SO2R
      SCHXR = SCHXR + CHXR
      SXNOR = SXNOR + XNOR
      SAEOR = SAEOR + AEOR
C
C     NACH PRIMAER-ENERGIE-TRAEGERN
C
C     SOLID FUEL
      SCOMS = SCOMS + COMS
      SCO2S = SCO2S + COMS
      SSO2S = SSO2S + SO2S
      SCHXS = SCHXS + CHXS
      SXNOS = SXNOS + XNOS
      SAEOS = SAEOS + AEOS
C
C     LIQUID FUEL
      SCOML = SCOML + COML
      SCO2L = SCO2L + CO2L
      SSO2L = SSO2L + SO2L
      SCHXL = SCHXL + CHXL
      SXNOL = SXNOL + XNOL
      SAEOL = SAEOL + AEOL
C
C     GASEOUS FUEL
      SCOMG = SCOMG + COMG
      SCO2G = SCO2G + CO2G
      SSO2G = SSO2G + SO2G
      SCHXG = SCHXG + CHXG
      SXNOG = SXNOG + XNOG
      SAEOG = SAEOG + AEOG
C
C     OF TOTAL
      SCO= SCOM  +COMTOT
      SCO2  = SCO2  +CO2TOT
      SSO2  = SSO2  +SO2TOT
      SCHX  = SCHX  +CHXTOT
      SXNO  = SXNO  +XNOTOT
      SAEO  = SAEO  +AEOTOT
C
      DEMS(1,NJ)=SCO2
      DEMS(2,NJ)=SSO2
      DEMS(3,NJ)=SCHX
      DEMS(4,NJ)=SXNO
```

```
      DEMS(5,NJ)=SAEO
C
C
      DEMT(1,NJ)=CO2TOT
      DEMT(2,NJ)=SO2TOT
      DEMT(3,NJ)=CHXTOT
      DEMT(4,NJ)=XNOTOT
      DEMT(5,NJ)=AEOTOT
C
C
C
C
      SRAU = SRAU + RADU
      SRAP = SRAP + RADP
      SRAF = SRAF + RADF
      GSO2E = SO2E *FGSO2E
      GSO2H = SO2H *FGSO2H
      GSO2T = SO2T *FGSO2T
      GSO2I = SO2I *FGSO2I

      GSO2I = SO2I *FGSO2I
      GSO2R = SO2R *FGSO2R
      GAEOE = AEOE *FGAEOE
      GAEOH = AEOH *FGAEOH
      GAEOT = AEOT *FGAEOT
      GAEOI = AEOI *FGAEOI
      GAEOR = AEOR *FGAEOR
      GSO2=GSO2E+GSO2H+GSO2T+GSO2I+GSO2R
      GAEO=GAEOE+GAEOH+GAEOT+GAEOI+GAEOR
      SGSO2=SGSO2+GSO2
      SGAEO=SGAEO+GAEO
      TRSO2=SO2RE+SO2RH+SO2RT+SO2RI+SO2RR
      TRAEO=AEORE+AEORH+AEORT+AEORI+AEORR
      SRSO2=SRSO2+TRSO2
      SRAEO=SRAEO+TRAEO
C
C
      IF(NJ.NE.1) GOTO 100
      TRSO2=0.0
      TRAEO=0.0
100   DEMR(1,NJ)=TRSO2
      DEMR(2,NJ)=TRAEO
      DEMR(3,NJ)=GSO2
      DEMR(4,NJ)=GAEO
      DEMN(1,NJ)=RADU
      DEMN(2,NJ)=RADP
      DEMN(3,NJ)=RADF
C
C
      DEMNS(1,NJ)=SRAU
      DEMNS(2,NJ)=SRAP
      DEMNS(3,NJ)=SRAF
      RETURN
      END
```

```
      SUBROUTINE ZERO
      COMMON / SUM/ SCOME,SCO2E,SSO2E,SCHXE,SXNOE,SAEOE,
     2              SCOMH,SCO2H,SSO2H,SCHXH,SXNOH,SAEOH,
     3              SCOMT,SCO2T,SSO2T,SCHXT,SXNOT,SAEOT,
     4              SCOMI,SCO2I,SSO2I,SCHXI,SXNOI,SAEOI,
     5              SCOMR,SCO2R,SSO2R,SCHXR,SXNOR,SAEOR,
     6              SCOMS,SCO2S,SSO2S,SCHXS,SXNOS,SAEOS,
     7              SCOML,SCO2L,SSO2L,SCHXL,SXNOL,SAEOL,
     8              SCOMG,SCO2G,SSO2G,SCHXG,SXNOG,SAEOG,
     9              SCOM ,SCO2 ,SSO2 ,SCHX ,SXNO ,SAEO,SGSO2,SGAEO,
     1              SRSO2,SRAEO
C
C     LOESCHEN ALLER SUMMENFELDER
      SCOME=0.0
      SCO2E=0.0
      SSO2E=0.0
      SCHXE=0.0
      SXNOE=0.0
      SAEOE=0.0
      SCOMH=0.0
      SCO2H=0.0
      SSO2H=0.0
      SCHXH=0.0
      SXNOH=0.0
      SAEOH=0.0
      SCOMT=0.0
      SCO2T=0.0
      SSO2T=0.0
      SCHXT=0.0
      SXNOT=0.0
      SAEOT=0.0
      SCOMI=0.0
      SCO2I=0.0
      SSO2I=0.0
      SCHXI=0.0
      SXNOI=0.0
      SAEOI=0.0
      SCOMR=0.0
      SCO2R=0.0
      SSO2R=0.0
      SCHXR=0.0
      SXNOR=0.0
      SAEOR=0.0
      SCOMS=0.0
      SCO2S=0.0
      SSO2S=0.0
      SCHXS=0.0
      SXNOS=0.0
      SAEOS=0.0
      SCOML=0.0
      SCO2L=0.0
      SSO2L=0.0
      SCHXL=0.0
      SXNOL=0.0
      SAEOL=0.0
      SCOMG=0.0
      SCO2G=0.0
      SSO2G=0.0
      SCHXG=0.0
```

```
SXNOG=0.0
SAEOG=0.0
SCOM =0.0
SCO2 =0.0
SSO2 =0.0
SCHX =0.0
SXNO =0.0
SAEO =0.0
SGSO2=0.0
SGAEO=0.0
SRSO2=0.0
SRAEO=0.0
RETURN
END
```

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